Kinetic Tests

- Kinetic tests accelerate weathering and provide acid production and consumption, and effluent chemistry data.
- Many lab and a few field tests are available.
- No single test produces all of the data needed to evaluate all mine wastes under all disposal conditions.
- Test procedures are complex, time-consuming, and require skill to produce consistent results.

Kinetic tests (as of 2003)

- Conventional and modified conventional humidity cells (ASTM).
- Steffan Robertson, and Kirsten humidity cells.
- Soxhlet extractions.
- Column leach tests.
- Shake flask extractions.
- Modified B.C. Research tests.
- Simulated environment studies (tons of waste left on a pad for months or years).

What they do

- They try to make a mine waste sample generate acid.
- They provide data about how long it will take for a sample to generate acid.
- They provide data on sample effluent chemistry.

How they are run

- Samples are leached periodically, the leachate is collected and analyzed.
- Acid generation rates, metals release, and neutralization capacity depletion are computed.
- Sample mass, particle size, test conditions (lab vs. field), and test duration varies greatly among methods.
- Kinetic tests should be supplemented by other test data (e.g., static test data, mineralogy, total metals data, etc.).

Ground rules

- Accepted criteria are generally lacking for interpreting kinetic test results.
- Data ranges from relatively straightforward to extremely difficult to interpret.
- All interpretations should include knowledge of sample mineralogy, static test data, particle size characteristics, and water flow.

Humidity Cells

- The conventional humidity cell (Sobek et al., 1978) is a bench-scale lab test.
- Between 200 to 300 g of crushed sample (<2 mm) is placed in a sealed plastic box.
- Dry air is passed over the sample for 3 days, followed by moist air for 3 days.
- Every seventh day, the sample is flushed with a specified volume of water (e.g., 0.5 or 1.0 liters).

Humidity Cells

- Slightly acidic water may be used to simulate acid rain.
- Leachate is collected and analyzed for sulfate, pH, acidity, alkalinity, and electrical conductivity.
- The 7-day process is repeated for 10 to 20 weeks.

ASTM Humidity Cells

- ASTM procedure D5744-96 was designed for mining wastes and uses a modified column as a humidity cell.
- A kilogram of sample is crushed to particle sizes smaller than 6.3 mm (1/4 inch).

ASTM Humidity Cells

- The test uses the Sobek leaching method and is run for 20 weeks.
- The test requires pre- and post-leach mineralogical and chemical characterization of the sample.
- There is an option for a bacterial spike.

Soxhlet Test

- Soxhlet reactors recirculate water or other fluids through a sample to simulate weathering.
- The test uses distilled water at 25°C to leach a sample over a period of six weeks, although the test duration can vary.
- Soxhlet extractions require sophisticated equipment and considerable operator skill.
- An independent evaluation indicated reliable results for tailings samples are possible.

Column Tests

- Column tests are not standardized.
- They permit a variety of column designs, test material characteristics, leaching cycles, and flow rates.
- “Standard” columns are 15 cm in diameter and 2 m in length but larger diameters and lengths are common.
- Particle size range up to 2 cm and sample masses up to several tons are common.
- The effects of bacteria inoculation, waste blending, flow channeling, etc. may be evaluated using column tests.

Column Tests

- Columns model precipitation infiltration into and drainage from mine waste exposed to the atmosphere.
- A fixed amount of water may be added in fixed or variable amounts on a regular or irregular basis.
- Water may be added to specific portions of the column surface to promote flow along preferred pathways.
- Columns model water infiltration into and drainage from mine waste disposed of under water.

Column Tests

- Columns model downward displacement of mine waste pore water by supernatant water to simulate seepage to ground water.
- They can model mine waste behaviour under submarine and deep lake disposal conditions.
- In general, all tests distinguish potentially reactive materials from benign materials but the leachate compositions may not resemble what is produced under natural settings.

Shake Flask (aka batch reactor)

- Samples are powdered and immersed in distilled water, they may be inoculated with bacteria.
- The flask is sealed and vibrated (for days to weeks).
- Samples are removed periodically and analyzed for sulfate, pH and other parameters.
- Water is added for long duration tests.
- The test is simple and inexpensive.

Field tests

- Field test samples range from hundreds of kilos to metric tons.
- Tests are run for years under natural climatic conditions.
- Long duration tests attempt to overcome inherent neutralization, bacterial oxidation lag time, and short term climate variability.
- Effluent samples are collected with lysimeters or from impermeable liner sumps.
- Test piles are constructed similar to actual or proposed waste rock dumps or tailings impoundments.

Field tests

- Field test provide mass release rates of metals per unit mass of waste data.
- Field tests provide realistic acid generation and neutralization rates and water quality data compared to bench-scale lab tests.
- Control options, such as limestone addition, can be tested under natural conditions.
- Test duration must smooth out short-term climatic variation effects.
- Long test duration makes these tests difficult to use, especially for evaluating proposed actions.

Interpretation
Ground rules

- Accepted criteria are generally lacking for interpreting kinetic test results.
- Data ranges from relatively straightforward to extremely difficult to interpret.
- All interpretations should be based on knowledge of sample mineralogy, static test data, particle size characteristics, and water flow.

Scaling

- Scaling is a significant issue for bench-scale kinetic tests because they accelerate natural weathering.
- Samples generate acid sooner than waste would in its disposal environment.
- Test leachates have higher metal concentrations.
- For bench-scale tests, leachate pH below 3 indicates strong acid generation; leachate pH between 3 and 5 indicates acid generation with some neutralization; and and leachate pH above 5 indicates no significant acid generation (or excess alkalinity overwhelms acid generation).

Temporal trends

- Leachate trends (e.g., pH, sulfate, acidity, alkalinity, and trace metals) are used to identify acid drainage progression.
- Leachate composition trends reflect changing sample mineralogy and geochemical equilibrium conditions.
- Equilibrium chemical speciation programs (e.g., MINTEQA2) that take into account precipitation/dissolution reactions, should be used to evaluate leachate composition trends.

Interferences

- Soluble sulfate minerals can mask sulfate produced by sulfide oxidation.
- Oxidation products contribute metals to kinetic test leachates. Metal hydrolysis can lead to acidification unrelated to sulfide oxidation rates.

Test duration

- Kinetic tests must run long enough for neutralizing and accumulated oxidation minerals to dissolve, and to overcome the bacterial oxidation lag-time.
- Test are commonly run 20 weeks but longer test lengths (e.g., 40 weeks to 104 weeks) are gaining favor.
- In long-term studies, some samples did not begin to produce acidic drainage until more than two years into the kinetic tests.

Sample particle size

- Particle size strongly influences kinetic test results.
- Smaller particles have high surface area but low water and air flux rates; both affect reaction rates and drainage quality.
- Acid generating and neutralizing minerals are liberated from finely ground samples.

Summary

- Kinetic test data are equivocally because of differences between samples and wastes (e.g., waste versus sample masses, particle size differences, particle separation distances, infiltration rates, flushing rates, and flushing volumes).
- Extrapolating test results to disposal-length time frames is risky.
- Changes in initial sample mineralogy plays a pivotal role in controlling leachate quality but is not address by kinetic tests.
- Properly applied mathematical models are useful for determining the potential effects of waste rock and tailings piles runoff.
- Modeling, however, is an advanced subject.